MINIMUM CORE CONFIGURATION WITH IRT-3M FUEL

IN THE VR-1 REACTOR

K.MATĚJKA, Ľ.SKLENKA, A.KOLROS, J. RATAJ

Department of Nuclear Reactors, Faculty of Nuclear Sciences and Physical Engineering, Czech Technical University in Prague, Czech Republic, e-mail: matej@troja.fjfi.cvut.cz

ABSTRACT

The present paper shortly describes advances of the RERTR program in the Czech Republic. The minimum core configuration B2 with 9 fuel elements IRT-3M and Beryllium reflector was performed on the training reactor VR-1 Sparrow. The paper presents results of reactor calculations and experimental measurements on the core configuration B2, their evaluation as well as the operation experiences with the Russian fuel assemblies IRT-3M on the reactor VR-1.

1.   Introduction

The status of the RERTR program in the Czech Republic in the summer 1999 can be characterized as following: Both reactors (the research reactor LVR-15 in the Nuclear Research Institute in Rez and the training reactor VR-1 Sparrow in the Czech Technical University in Prague) are operated with fuel assemblies of type IRT, enrichment 36%. The reactor LVR-15 uses the IRT-2M type of fuel and the reactor VR-1 has assemblies IRT-3M. This means that the current status remains same as in the second half of the last year. However, in the next several years we assume to fulfill the last four main steps:

- The changes of the type IRT-2M into IRT-3M (enrichment 36%) in the research reactor LVR-15 (at first into mixed core IRT-2M and IRT-3M, later into core IRT-3M only).
- The changes of the type IRT-3M into IRT-4M (enrichment bellow 20%) on the training reactor VR-1. The type IRT-4M (Russian production) is not prepared yet. The fuel assemblies IRT-3M from the reactor VR-1 will be used in the reactor LVR-15.
- The changes of the type IRT-3M into IRT-4M (enrichment below 20%) in the research reactor LVR-15 (at first into mixed core IRT-3M and IRT-4M, later into core IRT-4M only).
- The end of the RERTR program in the Czech Republic.

The standard core configuration on the reactor VR-1 is now of type B1 (Fig.1), which may be modified into core configuration B1M (Fig.2) for example in case of calibration of the reactivity meter for the NPP Temelin. In the first half of this year, a special critical experiment was prepared with a minimal possible number of fuel assemblies (only 9) and Beryllium
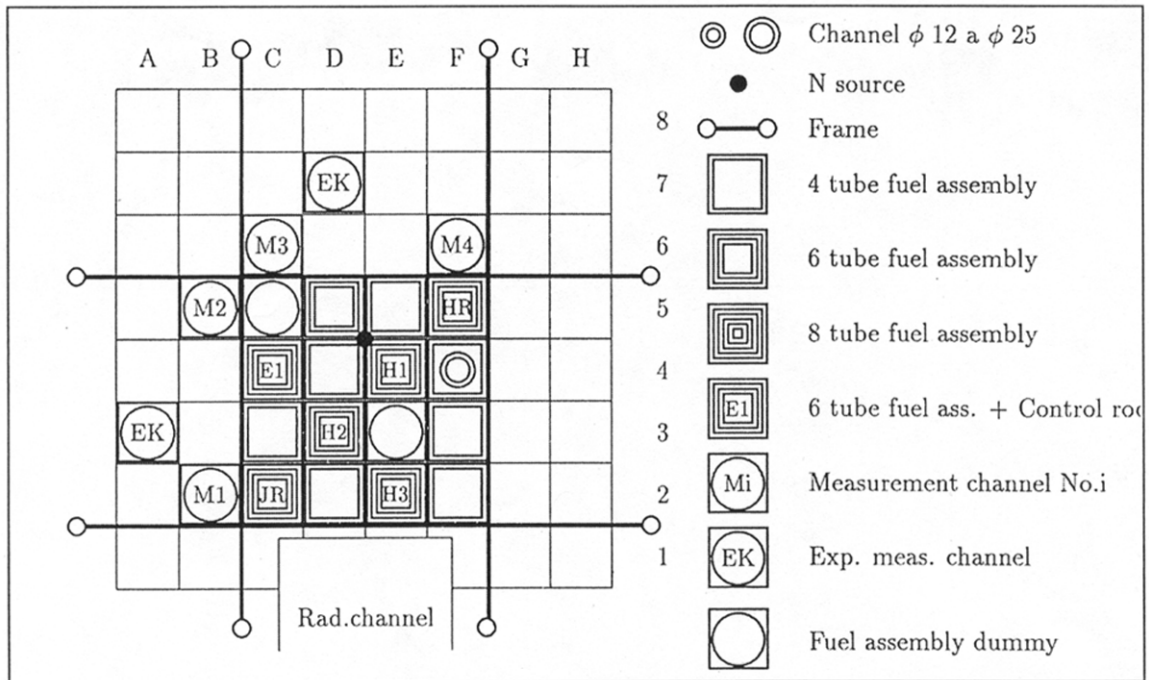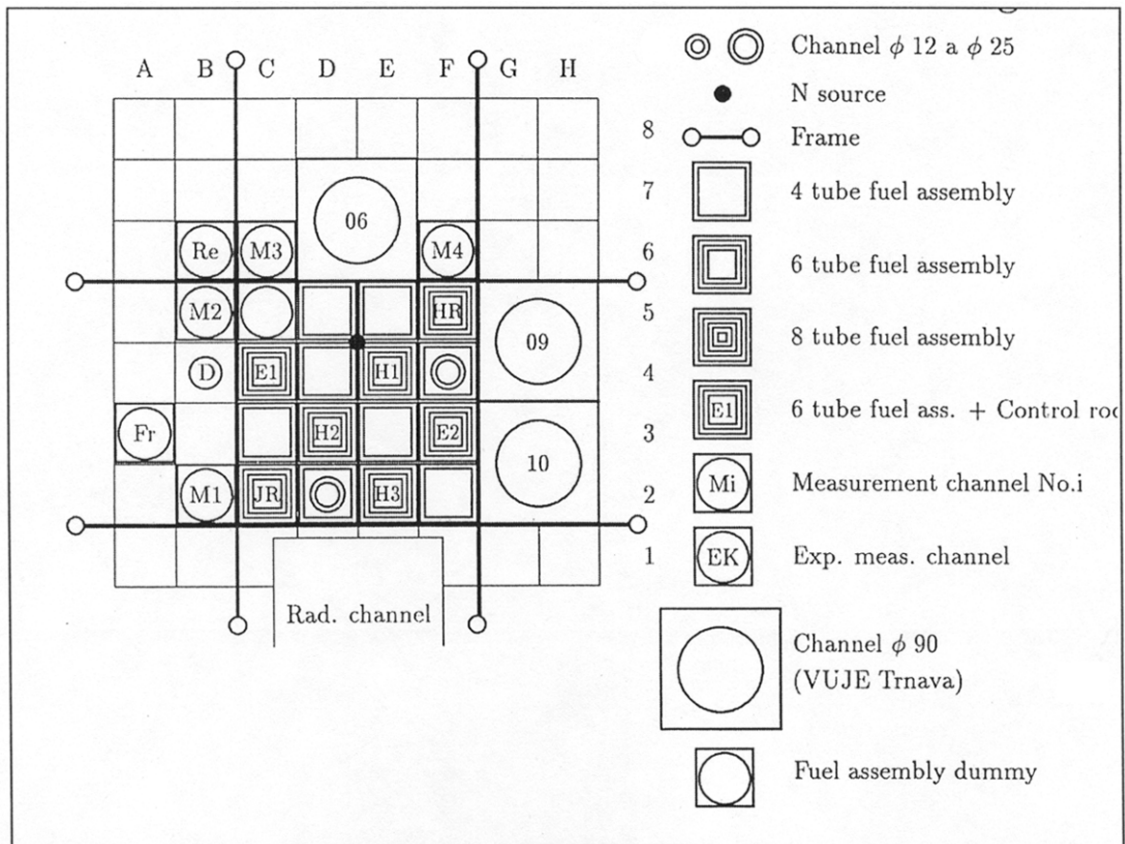
Fig. 1: Standard B1 Configuration

Fig. 2: B1M Core for NPP Temelin Reactimeter Testing

reflector. A core configuration was determined by the possibilities of the reactor laboratory and by the requirement for the comparison of experimental and calculation (MCNP code) data.

The program of critical experiment was prepared in accordance with the Czech regulatory body (State Office for Nuclear Safety) conditions and was realized in June 1999. The new core configuration was identified as B2 (Fig.3).

2. The Core B2 Construction and the Approaching to Criticality

The minimal number of control rods required by the limits and conditions for safety operation of VR-1 training reactor is 5 (3 emergency, 1 coarse, and 1 fine rods). The control rods are used in six tube fuel assemblies IRT-3M. With respect to symmetry of core configuration and preliminary calculation, the chosen minimal core configuration was an arrangement with 2 eight tube assemblies and 7 six tube assemblies in lattice 3 x 3. Since the 3 x 3 arrangement is relatively deeply subcritical the Beryllium blocks had to be used as a side neutron reflector. Be blocks have geometry of IRT-2M assemblies. Some of these blocks have a central cavity, which has been fulfilled by Be cylinder. The prepared core configuration was then consulted with Russian experts.

The construction of the core B2 is shown on Fig. 4, the approaching to criticality (step by step) on Fig. 5. After achieving criticality all main parameters of the new core including the weight of all control rods were measured. For comparison of the calculation and experimental data, the weight (reactivity) of neutron detectors, Be blocks and some experimental equipment near core were measured as well. Reactivity was measured by SOURCE JERK method in subcriticality and by ROD DROP method in criticality. The VR-1 reactor laboratory uses these experimental methods very often. Tab.1 presents typical representative results.

After finishing the critical experiment, the core B2 was disassembled. The reactor VR-1 is operated now with standard core B1 again.
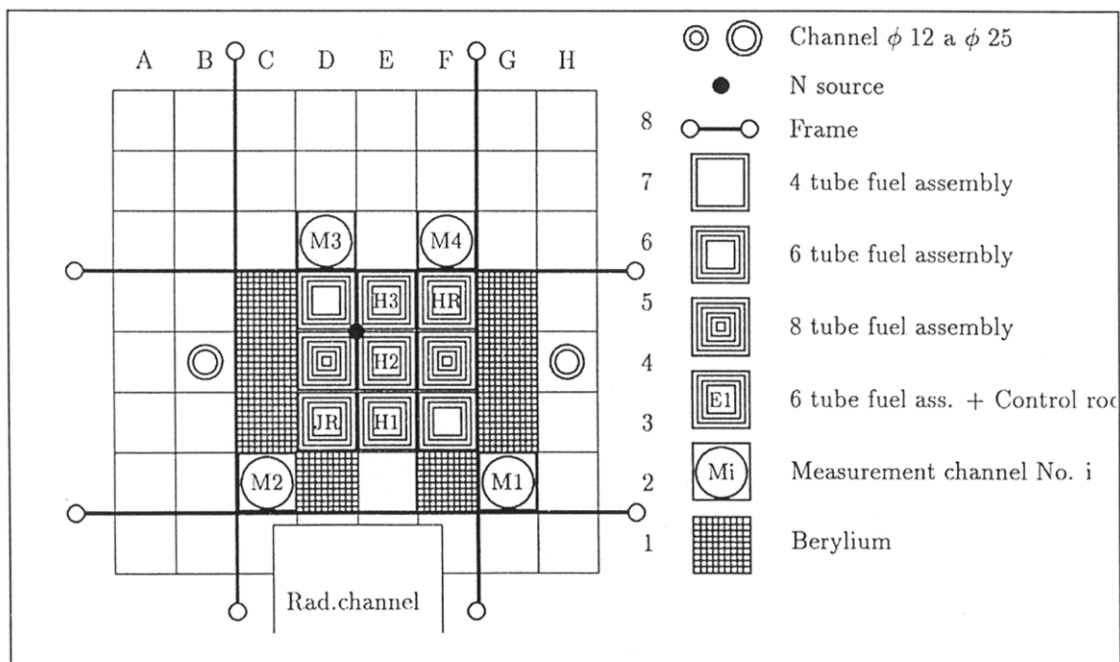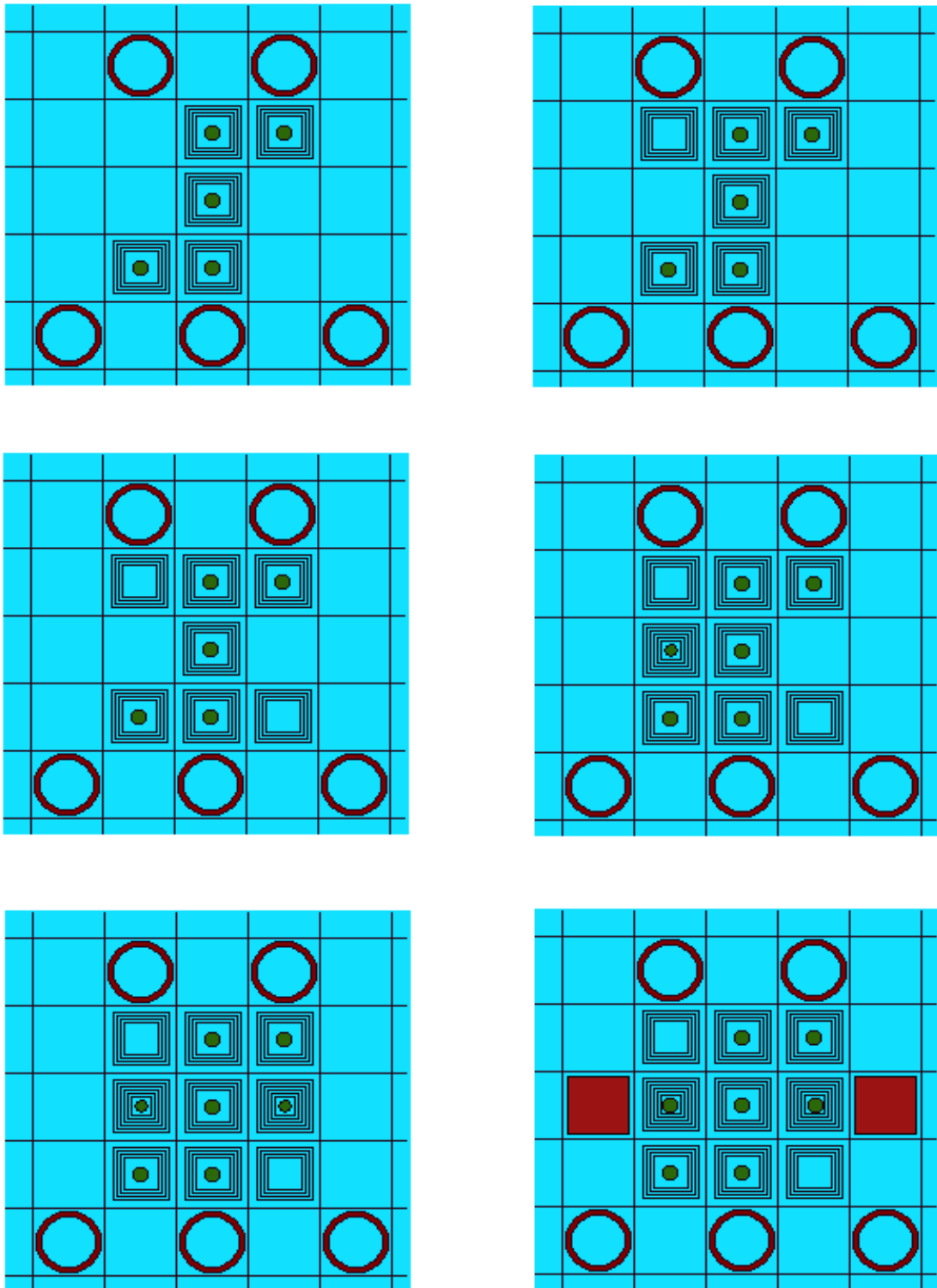

Fig. 3: Minimum B2 Core Configuration

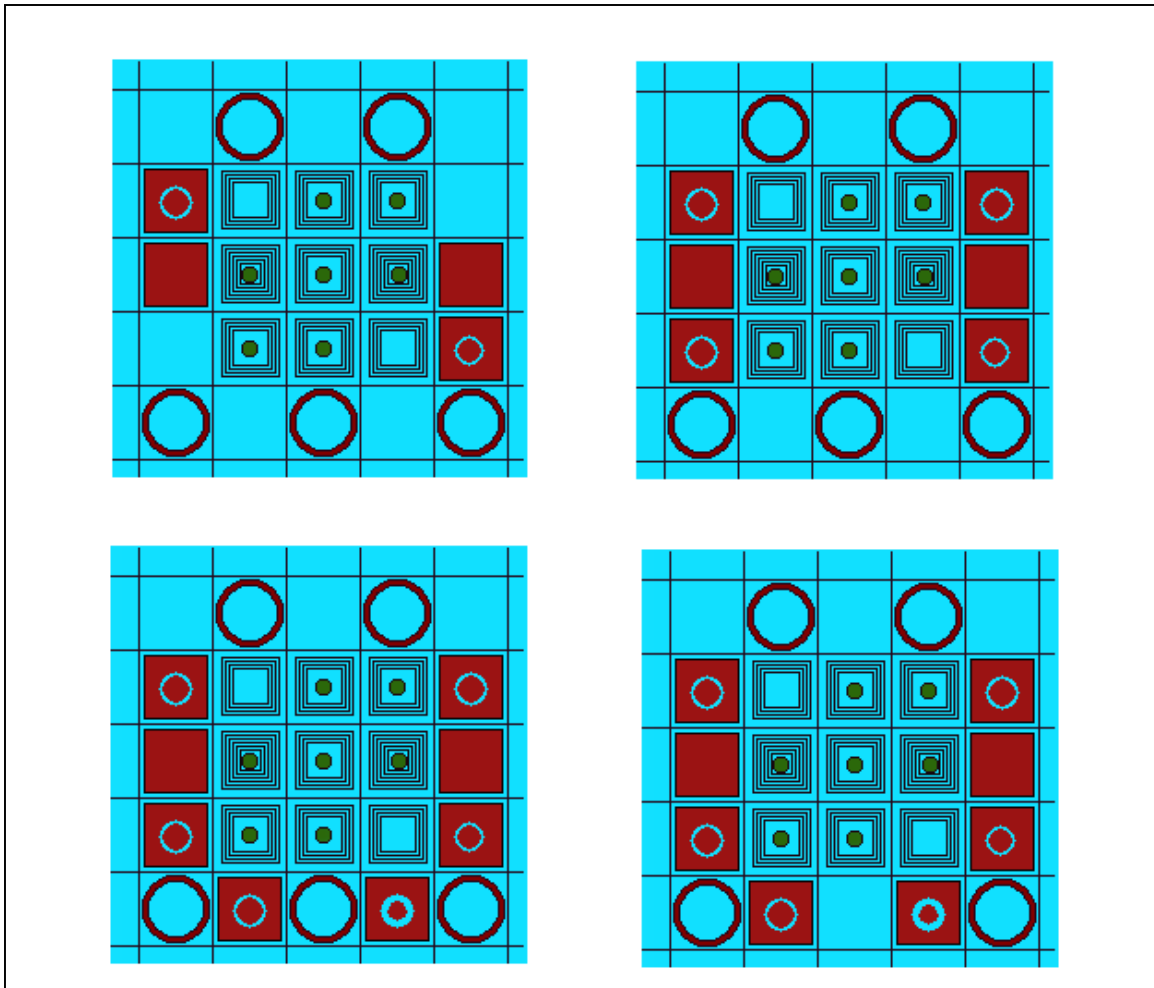**Fig. 4a:** The construction of the core B2

Fig. 4b: The construction of the core B2

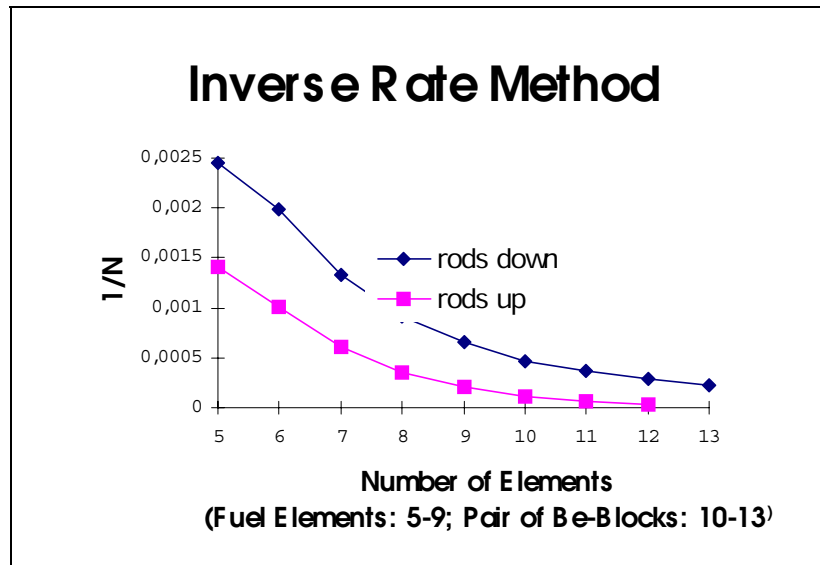**Fig. 5:** Approaching of B2 Core to Criticality

Calculation Results (9 fuel elements and 6 Be-blocks)

	k_{ef}		σ	ρ [β_{ef}]	
rods up	0,98847		0,00123	-1,67	
weight of rods [β_{ef}]	H1 5,10	H2 3,01	H3 3,28	JR 2,94	HR 3,03

Experimental Results (9 fuel elements and 6 Be-blocks)

Source Jerk ; rods up	n/200s		ρ [β_{ef}]	
Measure 1	22793		-1,97	
Measure 2	23346		-2,00	
weight of rods [β_{ef}]	H1 2,68	H2 1,81	H3 1,73	JR 1,25	HR 1,25

Mass of Uranium235 : 2 842,7   g
Mass of Uranium238 : 5 050,71 g
Total Mass   : 7 893,41 g

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3. Conclusions

The experience with the critical experiments and obtained results lead to following conclusions:
- The critical experiment with the core configuration B2 was successful. The position of control rods in state of criticality was close to the results expected by the preliminary calculations.
- A good agreement between calculation and experimental results was especially near the criticality state. The discrepancies were possibly caused by not-so-accurate account of relatively big neutron detectors and by the allowed tolerances of fuel size.
- The critical experiment enhanced the knowledge of neutronic parameters of IRT-3M fuel type.

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